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Investigating Activity Patterns and Time Spent for Exposure Assessment of College Buildings in Korea

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Abstract

The information about daily activity and time use patterns provide benefit on the analysis of environmental pollutant within microenvironment. The primary objective of this research is to present the relationship between exposure and activity patterns and time spent of individuals. College campus is unique area where students decide activities and spend time respect to them on campus. Dongnam Health College (DHC), as a case study, conducted a student activity survey and observed indoor air quality indicators at individual building. From the result, as student population increases at each building, the concentration of fine-dust and Co2 increases as well. We found that the student population changing time of day is highly correlated with indoor pollutant and also found that the level of concentration varies by time of day as well as day of the week.

Keywords: Activity pattern, Activity survey, Exposure assessment

1. Introduction

Recently in the field of personal exposure studies, the individual daily activity and time spent have been greatly concerned. The information about activity and time spent provide benefit on the analysis of pollutant within

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microenvironment. The activity time spent in microenvironments plays a critical role for personal exposure to environmental pollutants. While there are several large scale activity pattern studies in Western countries, comprehensive time activity pattern research for exposure assessment has not been readily available in Korea. The main purpose of this study is to investigate the relationship between activity population and exposure measures such as dust, Co2, temperature, and humidity. In order to test the relationship, we focused on college campus (Dongnam Health University) as a case study to perform student activity survey and to measure exposure indicators for a one-week period. The relationship between student activity population with respect to college buildings and exposure indicators are presented by time of day.

2. Data

According to 2012 statistics, Dongnam Health University (DHU) student population is 4,570 which include freshman, sophomore, and junior. A random 11.2% sample of students representing the total DHU student population was selected, and they were asked to complete a travel diary for one school day. 514 students returned by mail the survey questionnaires. They were asked to complete an activity diary for one school day between April 4 and 30, 2012. The questionnaires collected data on student characteristics (gender, age, and status – freshman, sophomore, junior), location of daily activities. The questions included demographic information and activity-time use patterns. The activities consist of 6 major classifications: Work (class, lab, etc.), Study (personal), Exercise, Recreation, Club, and Other.

The descriptive summary statistics in Table 1 show that more female (70.4%) and freshmen students (58.4%) were sampled since the composition of female students was doubled compared to male students. Also, the numbers of junior student are relatively few since most of department at DHU has two-year education courses.

TABLE 1 Descriptive Statistics of Student Characteristics

Variable	Description	No. sample	Statistics
Age	Average age		21.1
Gender*	Gender of student	Male	152 (29.6%)
		Female	362 (70.4%)
Student status*	Educational status	Freshman	300 (58.4%)
		Sophomore	174 (33.9%)
		Junior	40 (7.7%)

Note: The variables with an asterisk are categorical.
Statistics of categorical variables are denoted as frequency (percentage).

3. Activity characteristics

The frequency of activity types by trip purpose is presented in Table 2. As expected, the most frequent activity in daily student life is Work/Study. Of 1718 activities, 893 (about 52%) corresponded to college work-related activities including purposes School/Class, and Study/Research. Besides work-related activities, Social/Recreation activities had high frequencies. Table 2 also summarizes activities by average number per day, daily time allocations, and average travel time devoted to the activity. School, Study, and Work activities were allocated large proportions of daily time budgets. Note that the average duration of Work activity (about 4 hours per day) is about two times to the duration of Recreation plus Exercise/Club activities.

TABLE 2 Activity Characteristics

Activity	frequency	percent(%)	average number of activity	average duration(min)	average travel time(min)
Work	753	43.83%	1.46	236.50	8.17
Study	140	8.15%	0.27	36.77	2.22
Recreation	500	29.10%	0.97	112.06	13.77
Exercise	23	1.34%	0.04	4.67	0.93
Club	26	1.51%	0.05	7.59	1.17
Other	276	16.07%	0.54	63.04	10.86
total	1718	100.00%	--	--	--

Figure 1 illustrates daily activity-travel patterns of students, and the sequence of activities (activity profile) by student. Activity profiles show how many people engage in each activity in each hourly time frame during a day. In this study, for simplicity of analysis, each activity type is recorded every hour to create a daily activity profile. All activities are aggregated to six major activities: Work (class and research related activities); Study; Recreation (dining out and leisure activities); Exercise; Club (extra activity for hobby); and Other activities.

As shown in Figures 1 the daily activity profiles are developed and showed that daily activity patterns have an a.m. and a p.m. peak in Work activity. The peak hours appear later in the morning around 10 a.m. and earlier in the afternoon about 2 p.m. because of class schedules.

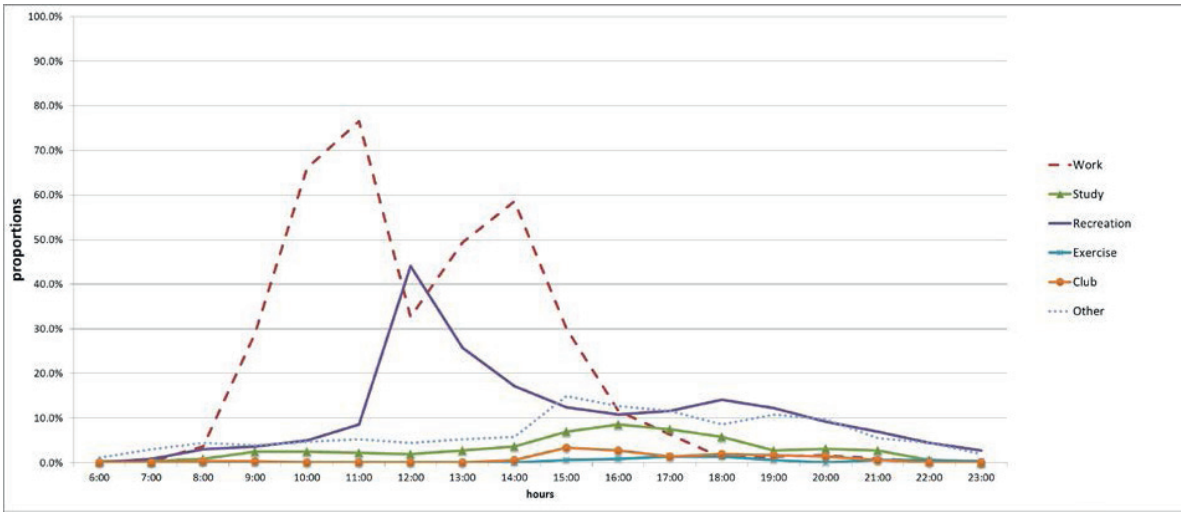

Fig.1 Activity participation by students

In order to estimate activity population, the number of students in each student group was identified from the college demographic information and the student population by grade group was applied to the activity schedule. The activity schedule aggregated by hourly segment provided the proportion of students engaged in each activity by hourly frame. The ratio of activity participation multiplied the number of students in each group, and then the number of students engaged in each activity in each hour was obtained. Finally hourly activity population at an individual building was estimated based on a simple function of the number of students in each traveler group, their corresponding activity schedules, and the building activity capacity. We developed maps for showing hourly changes of activity population on campus buildings as shown in Figure 2.

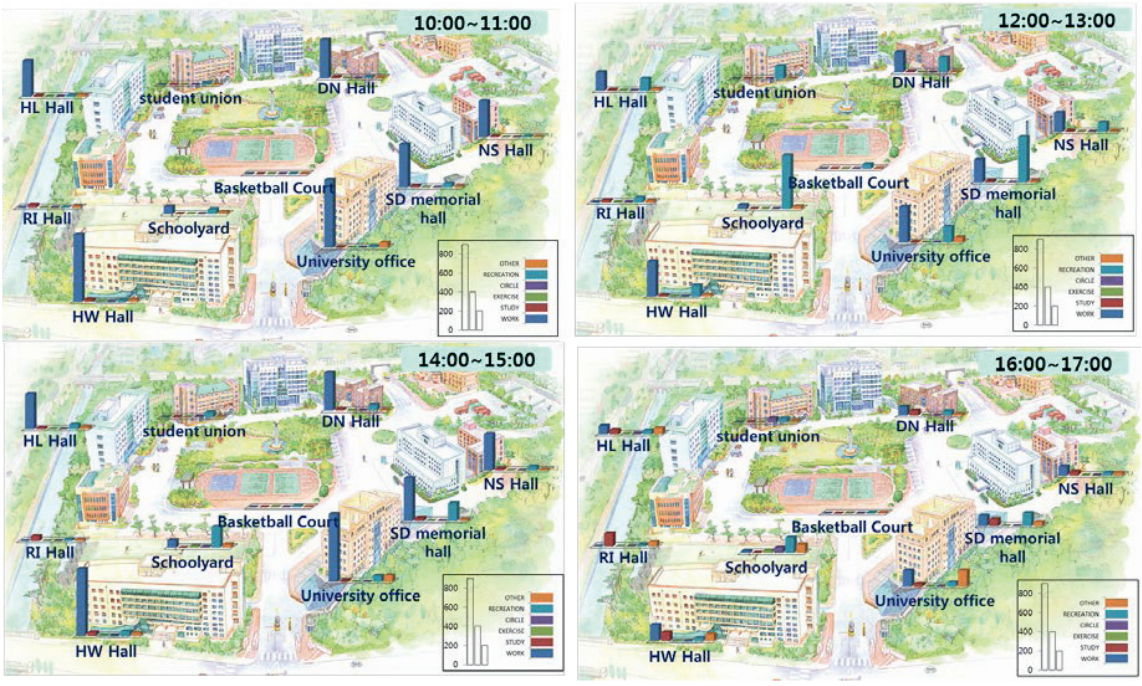

Fig.2 Comparisons of public transportation mode distribution

4. Exposure measures

In order to investigate the relationship between activity population and exposure measures, we compared activity populations by building against the exposure measurement observed at each building. As a case study, one of building used for restaurant was selected and we measured exposure indicators a restaurant and lobby. The level of concentration of hourly indoor fine-dust and Co2 for the case of student restaurant are shown in Figure 3. The exposure indicators measured at lobby were relatively shown to be stable compared to restaurant because the lobby is wide and open space. By comparing with activity population at both places, the exposure measures of fine-dust and Co2 were seen to be highly correlated with the number of student population. As expected during the lunch time between 12pm and 2pm student population increases at restaurant, the concentration of fine-dust and Co2 highly increases as well. However, the variations of temperature and humidity were not seen to be highly related to increase of student populations at restaurant. The temperature and humidity were slightly increased with activity population. Figure 4 shows the weekly exposure measures by college building, the differences on concentration of exposure indicators are observed depending on the student activity schedule by day of week. In this case study, we found that Thursday is shown to be the worst day for students with high concentration level of fine-dust and Co2 because many student classes are opened on Thursday.

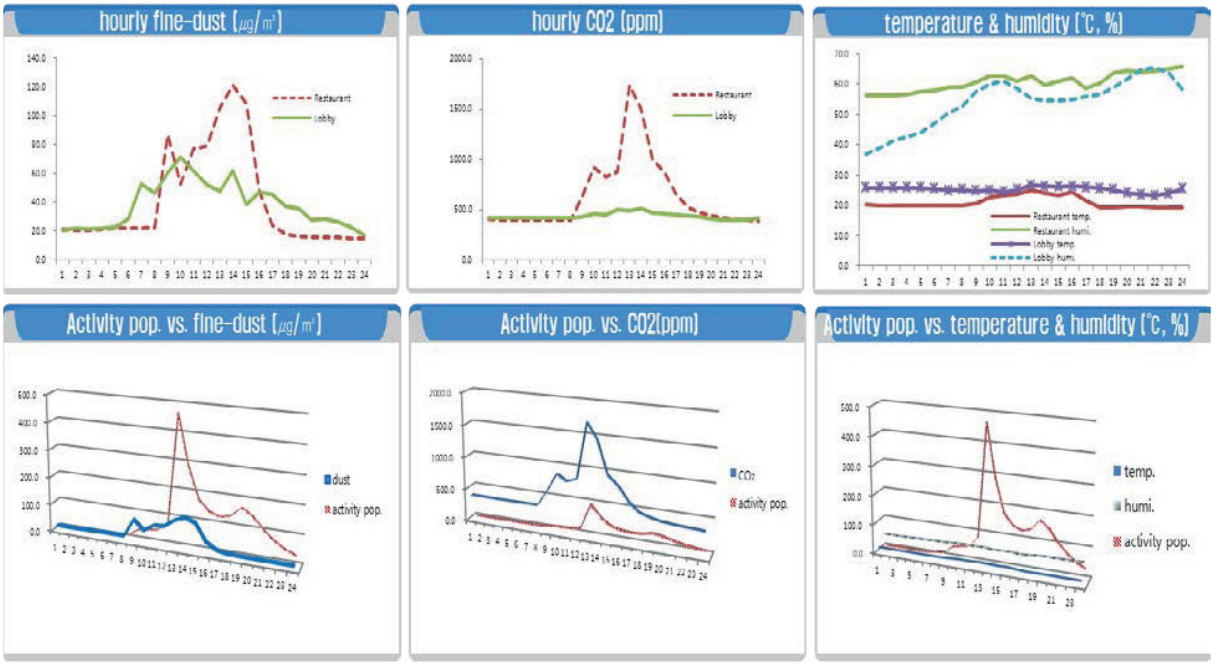

Fig.3 Hourly recreation activity populations and exposure measures at college restaurant

fine dust ㎍/㎥	RI Hall		HL Hall		Student union		SD memorial Hall		HW Hall	
	Lobby	Library	Restaurant	Computer room	Office	council room	Restaurant	Lobby	Restaurant	disposal plant
Mon	59.0	146.2	2.5	16.4	65.2	68.5	25.7	35.6	31.4	46.2
Thu	45.9	121.8	5.0	23.4	74.5	41.3	39.0	37.9	40.3	60.8
Wed	28.0	87.8	4.8	24.2	142.2	65.4	48.5	47.6	31.3	48.5
Thu	21.3	64.7	7.2	27.7	110.2	39.7	116.4	140.2	30.2	57.5
Fri	25.7	68.6	8.1	30.4	67.9	26.6	67.0	87.3	23.6	58.8
Sat	21.8	53.3	8.4	43.1	35.8	11.7	48.1	86.5	13.2	46.9
Sun	13.0	46.0	3.3	21.9	58.8	14.1	62.2	90.3	26.6	61.9
AVG	30.7	84.1	5.6	26.7	79.2	38.2	58.1	75.1	28.1	54.4

CO2 PPM	RI Hall		HL Hall		Student union		SD memorial Hall		HW Hall	
	Lobby	Library	Restaurant	Computer room	Office	council room	Restaurant	Lobby	Restaurant	disposal plant
Mon	544	2015	505	537	576	834	500	442	738	418
Thu	580	1634	506	740	490	666	636	436	587	404
Wed	436	1171	518	697	473	712	384	412	598	399
Thu	437	1276	508	615	461	604	749	453	624	396
Fri	487	1474	483	489	408	469	623	468	550	388
Sat	445	578	416	439	400	515	430	446	486	400
Sun	457	461	411	430	418	471	429	448	468	390
AVG	484	1230	478	564	461	610	536	443	579	399

℃	RI Hall		HL Hall		Student union		SD memorial Hall		HW Hall	
	Lobby	Library	Restaurant	Computer room	Office	council room	Restaurant	Lobby	Restaurant	disposal plant
Mon	19.3	25.3	23.5	25.5	23.3	24.0	20.7	25.4	25.6	22.0
Thu	20.9	25.6	23.9	25.5	23.0	24.6	21.0	25.2	25.0	21.9
Wed	19.3	25.0	23.2	26.3	23.2	23.8	19.0	26.0	25.0	22.0
Thu	17.4	23.1	21.6	26.5	23.5	25.4	21.6	25.3	25.3	22.3
Fri	18.3	25.0	21.1	25.5	22.1	23.1	22.6	25.0	25.4	22.3
Sat	20.9	23.5	19.7	26.2	22.1	26.0	20.5	26.1	26.1	22.3
Sun	22.0	23.5	19.3	26.2	22.0	25.0	20.4	26.3	26.0	22.1
AVG	19.7	24.4	21.8	26.0	22.7	24.6	20.8	25.6	25.5	22.1

humidity %	RI Hall		HL Hall		Student union		SD memorial Hall		HW Hall	
	Lobby	Library	Restaurant	Computer room	Office	council room	Restaurant	Lobby	Restaurant	disposal plant
Mon	69.0	59.4	47.8	37.6	34.6	34.8	53.3	37.0	63.1	72.7
Thu	59.4	51.2	51.9	43.6	34.1	32.8	60.6	53.9	61.3	72.8
Wed	60.9	48.9	54.3	46.2	46.9	46.7	68.8	55.7	58.8	68.5
Thu	48.7	42.4	51.3	43.4	45.7	42.6	69.1	59.0	59.0	69.8
Fri	35.7	32.8	51.7	40.9	46.3	44.0	65.8	61.3	59.3	68.6
Sat	40.1	35.8	49.7	37.6	46.0	39.3	62.6	58.8	61.8	72.8
Sun	51.8	48.5	48.1	31.7	50.9	43.5	63.3	56.2	60.4	67.9
AVG	52.2	45.6	50.7	40.1	43.5	40.5	63.4	54.6	60.5	70.4

Fig.4 Weekly exposure measures by college building

5. Conclusion

We investigated the relationship between indoor air quality and activity population on college building level based on activity survey data and found that activity population is highly correlated with the level of indoor air quality. Although the result does not provide detailed information about the correlation between them, we expect that the estimation of activity population will be useful for active management of air pollutant control by building level and need a further study for practical implications.

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